The Application of Multiple Modalities for Improved Home Care Reminders

David Warnock
Glasgow Interactive Systems Group,
School of Computing Science,
University of Glasgow, Glasgow, G12 8QQ, UK
warnockd@dcs.gla.ac.uk

Abstract
My work aims to contribute to the development of home care reminder systems through the development of dynamic multimodal notification technology, able to select a notification modality based on user, environmental and message factors such as sensory impairment and social context. This work involves *(1)* investigating different properties of notification modalities, (2) establishing guidelines for their use as notifications in the home, *(3)* creating a prototype dynamic multimodal home reminder system and (4) evaluating it in home trials. At present, work on part two is being completed and preparations have begun for the third part of this research.

Author Keywords
Multimodal; Notifications; Reminders; Home Care

CHI'12, May 5–10, 2012, Austin, Texas, USA.
ACM 978-1-4503-1016-1/12/05.

ACM Classification Keywords
H.5.2 [**Information Systems Applications**]: User Interfaces - *Interaction styles;*

Research Situation
I am Computer Scientist currently at the end of the second year of my PhD on a full-time program. I anticipate the remainder of the PhD will be completed over the next 12 to 16 months. My research is split into four main components:

1. An empirical investigation of various notification modalities evaluating their relative merits, shortcomings and performance.
2. The creation of guidelines on where, when and how they can be used to make effective and appropriate notifications.
3. The development of a home reminder system that can dynamically switch between modalities based on user, environmental and message factors.
4. Real-world trials of this prototype with end users.

The first part of this research has been completed. I am currently working towards the second goal and preparatory work is being carried out for the third goal. I hope that attending this doctoral consortium will help to highlight any weaknesses in the work I have already

carried out and guide my future work in developing and testing a new type of dynamic multimodal home reminder system.

Context and Motivation

Home reminder systems are designed to help people manage their lifestyle and environment by providing helpful notifications in and around the home; for example to remind users about appointments, unlocked windows, running taps, meals and medicine times. Notifications could even be used to promote healthy social behaviour such as phoning friends and family. This technology can help to maintain a high standard of living while reducing dependence on carers.

Designers of home care technology need to carefully consider how information is presented in the home; however, requirements for home care systems are often complex and can be subject to rapid change as medical conditions or sensory impairments develop or worsen [7,8]. Multimodal interaction can compensate for sensory impairment by delivering notifications via non-impaired channels.

Existing systems tend to be restricted to a few modalities and generally interact using static schedules, pre-programmed rules that determine what the system should do in a given situation (such as playing an audio beep if a bath overflows) [12]. A dynamic scheduler equipped with a wide range of notification modalities (and able to combine them for truly multimodal notifications) would be able to make decisions about *how* and *when* to deliver the message based on user, environmental and message factors (such as using non-audio modalities when there is background noise and the user has a hearing impairment). Many researchers have called for research into this subject [1,6,8].

Dynamically scheduling notifications in a range of modalities provides the flexibility needed to handle the complexities encountered in the home of a care recipient, such as rapidly changing medical, social and environmental contexts [6]. Improved home care reminder technology could lead to real-world enrichment of the quality of life for home care recipients.

Background and Related Work

Prior to my work the most extensive exploration of multimodal notifications was by Arroyo & Selker [1], who compared 5 modalities but reported only subjective results; they argued that individual differences are the most important factor when selecting a modality, and argued for technology able to dynamically switch between modalities to suit the user and environment. Individual modalities have generally been well researched (exceptions include smell and temperature), and as a result much is known about their performance and potential applications [3,4] while little is known about how they compare to a wider range of modalities. More research was needed that considered a wide range of modalities, addressed by my work in the first part of my research [13,14,15].

The creation of effective and acceptable technology for the home is an active area of research which has produced a number of guidelines [2,11]. Research has also been carried out into supporting care recipients at home with multimodal technology [6,8,9]. New guidelines are needed that will build on this knowledge

to inform the selection and configuration of multimodal notifications for home care systems.

Research has shown that dynamically reconfigurable technology can deliver notifications in a manner that is more acceptable to its users [8,10]. Vastenburg *et al.* [10] demonstrated that changing the salience of the delivery method based on the urgency of the message had a significant effect on user acceptability. Research into switching between modalities tends to consider two or three modalities, such as Hoggan *et al.'s* work in audio and tactile feedback [4]. In the third part of my work a prototype dynamic home reminder system will be developed, based on an existing system such as HOMER [5] and using the guidelines part two of my work to inform development.

Statement of Thesis or Problem

Home care reminder technology can be made more appropriate and effective through the implementation of multiple notification modalities and the ability to dynamically switch between them based on environmental, social and user factors.

Research Goals, Methods and Status

The first research goal has been accomplished by carrying out 3 experiments. A simple card-matching task was developed and used to explore the impact of notifications when delivered in different modalities. Notifications were either unwanted distractors or important messages that delivered instructions. Experiment 1 was exploratory, while experiments 2 & 3 compared younger (aged 18-30) and older (aged 50+) participants. All 3 experiments considered text, pictogram, abstract visual, speech, Earcon, Auditory Icon, tactile and olfactory modalities giving a clear overview of a range of interaction methods. It was found that modality does not influence primary task error rate or activity rate, significant differences exist between the ability of different modalities to deliver information, there were no differences between modalities in a cognitive workload assessment, distractor notification were as disruptive as useful notifications, regardless of modality, and that older users demonstrated the same behaviour as younger users. Papers on these findings have been accepted into several peer-reviewed publications [13,14,15].

The second research goal is the formulation of guidelines detailing which modalities should be used in a given situation, how they should be configured and how they will perform. This is currently in progress and involves combining the findings of the first part of my research with existing work on creating multimodal notifications [3,4] and technology for the home [2,10]. This is expected to be completed in November 2011.

The third research goal is to develop a dynamic multimodal home reminder system. This will use the existing HOMER system as a starting point [5]. To achieve this goal the system will be equipped with multiple modalities and programmed with a set of rules that allow for dynamic modality selection; these rules will be based on the guidelines produced by goal two. This is expected to be completed by the end of December 2011.

The fourth research goal is the evaluation of the prototype created by goal 3. This will be done in two stages; firstly controlled trials in a lab setting followed by real-world trials with end users. Lab trials will use an artificial environment and tasks to evaluate how

effective the prototype is at selecting notification modalities and delivering information. Real-world trials will begin after this to investigate how participants react to the technology in the home, how successful it is at helping with daily activities, and how effective it is at delivering notifications in a real-world setting. This is expected to be completed by July 2012 forming the natural endpoint of my PhD research.

The doctoral consortium would be of enormous benefit in exploring the guidelines I am creating and the design of my scheduler. My Thesis is currently in a very early outline/draft form, with content centred on the literature review and the first parts of my work.

Expected Contributions

The primary contributions of my work are the guidelines on developing multimodal notifications for the home and the validated home reminder system. I hope that this work will encourage designers and researchers to include multiple modalities and to create more effective and appropriate multimodal technology.

Acknowledgements

My research is funded by the EPSRC (grant number EP/G069387/1).

References

[1] Arroyo, E., Selker, T. and Stouffs, A. Interruptions as Multimodal Outputs: Which are the Less Disruptive? *Fourth IEEE Int. Conf. on Multimodal Interfaces*, (2002), 479-482.

[2] Edwards, W. and Grinter, R. At Home with Ubiquitous Computing: Seven Challenges. *Ubicomp 2001: Ubiquitous Computing*, Springer Berlin Heidelberg (2001), 256 - 272.

[3] Hellier, E., Edworthy, J., Weedon, B., Walters, K. and Adams, A. The Perceived Urgency of Speech Warnings: Semantics versus Acoustics. *Human Factors: The Journal of the Human Factors and Ergonomics Society 44*, 1 (2002), 1-17.

[4] Hoggan, E., Crossan, A., Brewster, S. and Kaaresoja, T. Audio or Tactile Feedback: Which Modality When? *27th Int. Conf. on Human Factors in Computing Systems*, ACM (2009), 2253-2256.

[5] Maternaghan, C. *The HOMER Home Automation System* (2010).

[6] McGee-Lennon, M.R., Wolters, M.K. and Brewster, S. User-Centred Multimodal Reminders for Assistive Living. *ACM CHI*, (2011).

[7] McGee-Lennon, M.R. Requirements Engineering for Home Care Technology Design. *Proc. of ACM CHI'08*, (2008), 1439-1442.

[8] McBryan, T. and Gray, P. *A Model-Based Approach to Supporting Configuration in Ubiquitous Systems*. 2008.

[9] Perry, M., Dowdall, A., Lines, L. and Hone, K. Multimodal and Ubiquitous Computing Systems: Supporting Independent-Living Older Users. *Information Technology in Biomedicine 8*, 3 (2004), 258-270.

[10] Vastenburg, M.H., Keyson, D.V. and Ridder, H. Considerate Home Notification Systems: A User Study of Acceptability of Notifications in a Living-Room Laboratory. *Human-Computer Studies 67*, 9 (2009), 814-826.

[11] Wang, F. and Turner, K. Towards personalised home care systems. *PETRA 282*, (2008).

[12] Wang, F., Docherty, L., Turner, K., Kolberg, M. and Magill, E.H. Services and Policies for Care At Home. *Pervasive Health*, IEEE, (2006).

[13] Warnock, D., McGee-Lennon, M. and Brewster, S. The Role of Modality in Notification Performance. *INTERACT* (2011), 572-588.

[14] Warnock, D., McGee-Lennon, M. and Brewster, S. The Impact of Unwanted Multimodal Notifications. *ICMI* (2011), 177-184.

[15] Warnock, D. A Subjective Evaluation of Multimodal Notifications. *Pervasive Health* (2011), 461-468.